Terra CRS Results and Status

CERES Science Team Meeting
Hampton, Virginia 17 Nov. 2003

Surface and Atmosphere Radiation Budget (SARB) group:
T. P. Charlock (NASA LaRC)
Fred G. Rose (AS&M)
David A. Rutan (AS&M) – validation and “CAVE” URL
Zhonghai Jin (AS&M) - coupled radiative transfer
Lisa H. Coleman (SAIC) - Data Management Team
Thomas E. Caldwell (SAIC) - Data Management Team
Wenying Su (H.U.)- spectral SW at surface

Seiji Kato (H.U.) – update on radiative transfer from last STM

Access to CAVE on line surface and CERES validation,
point and click Fu-Liou and COART calculations:
www-cave.larc.nasa.gov/cave/ or goggle “CERES CAVE”

Terra CRS Beta 5 from January 2001 to June 2001

available and partly validated.

Significant error in handling spectral variation of AOT over land

3 MODIS visible channels interpolated to near IR

Even with error, CRS Terra surface SW is probably better than TRMM

Product allows aerosol forcing estimates in clear and cloudy conditions

“Edition” version will correct aerosol bug and use improved ocean albedo

Significant improvements in SARB are put off to gridded Synoptic product

Spectral treatment of cryosphere comparable to present COART ocean optics

More sophisticated decision tree for land/snow/sea ice albedo using

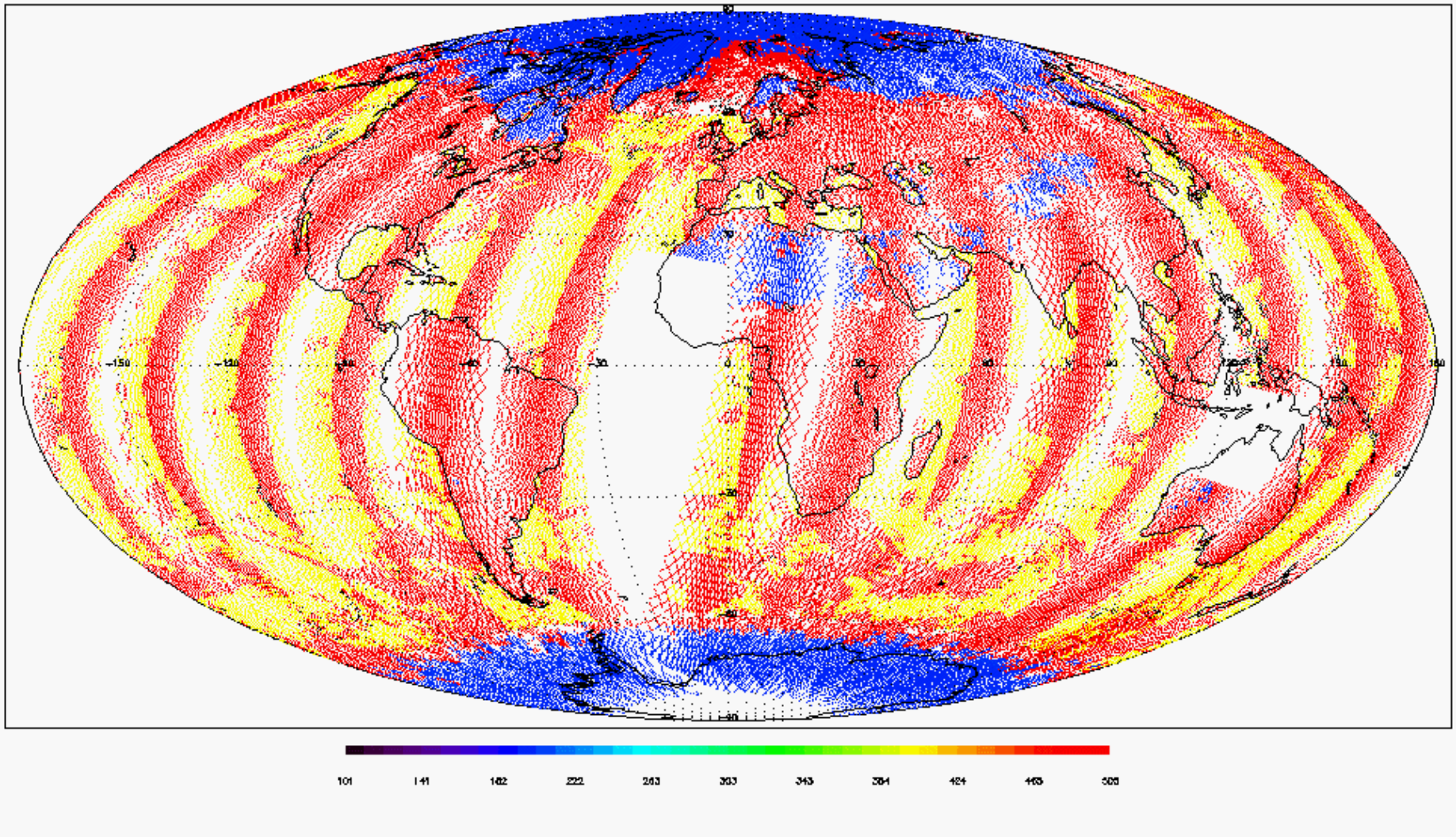
Cloud WG resources

Spectral SW at surface (resolved UV)

Height resolved MATCH input sought

Daytime sources of AOT on 1 April 2001

MATCH assimilation **MODIS instantaneous** MODIS interpolated

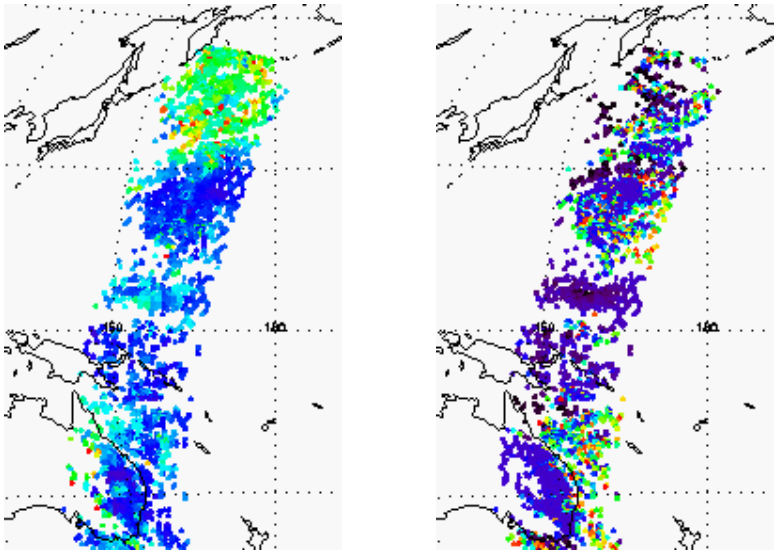


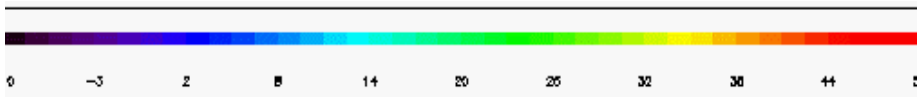
Aerosol forcings to reflected SW at TOA that can be evaluated with Terra CRS Beta5:

All sky aerosol forcing = (All sky with aerosols) - (All sky with no aerosols)

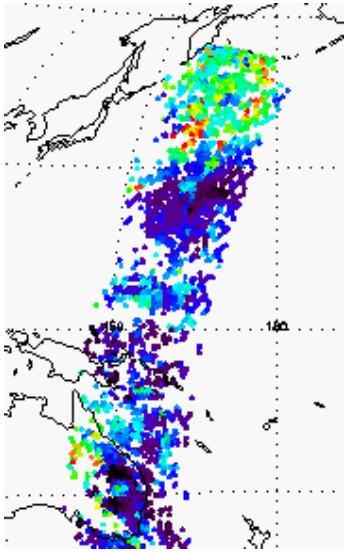
Clear sky aerosol forcing = (Clear sky with aerosols) - (Clear sky with no aerosols)

Cloud impact on aerosol forcing = (All sky aerosol forcing) - (Clear sky aerosol forcing)

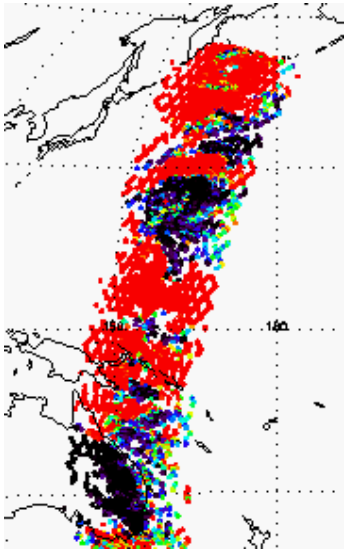




-10 +20 Wm-2 50



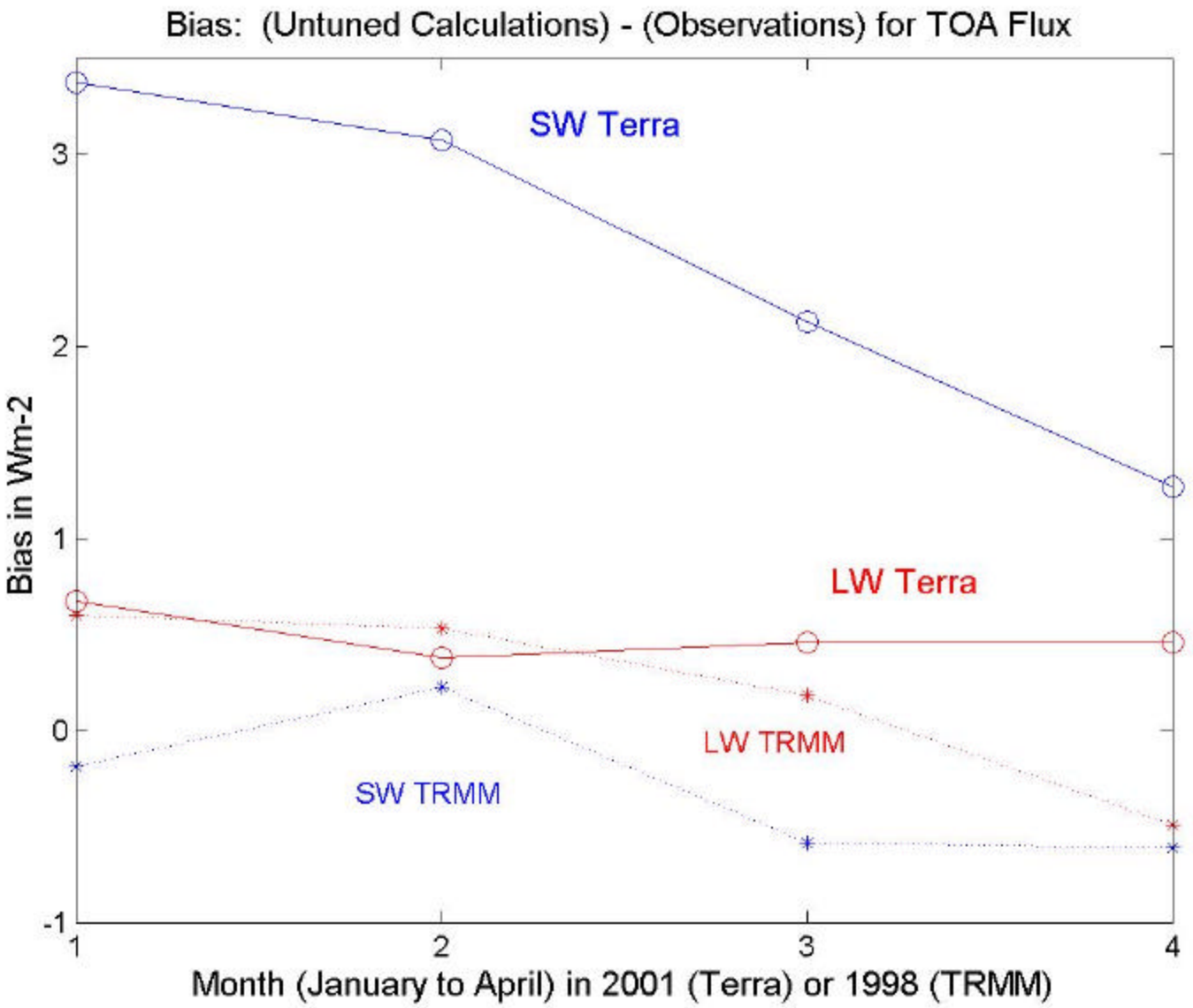
AOT 0.0--0.5



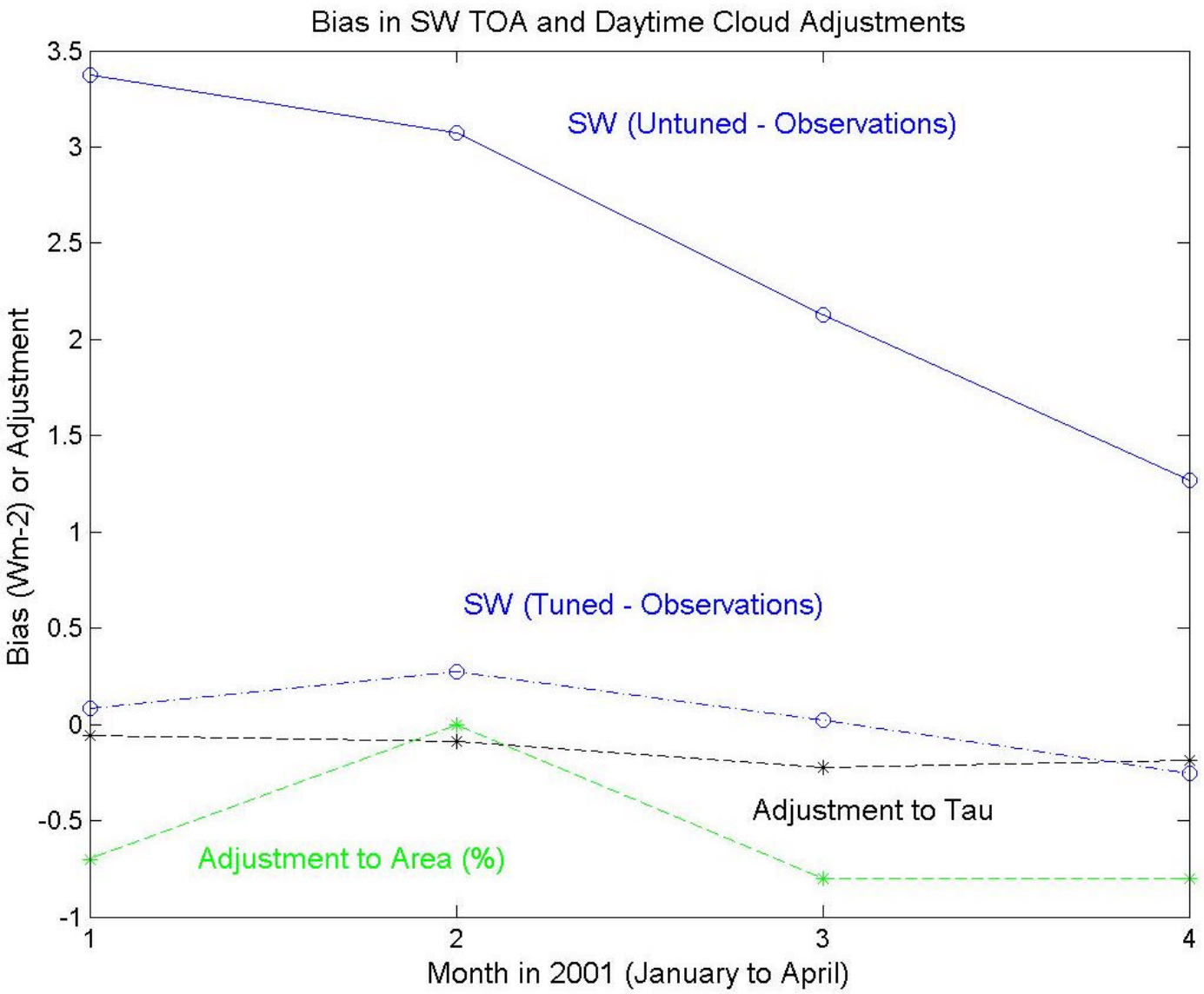
Cloud Area 0.0--1.0

Present output structure for "Cloud no AOT flux" is cumbersome; must be revised and include initial cloud fraction explicitly.

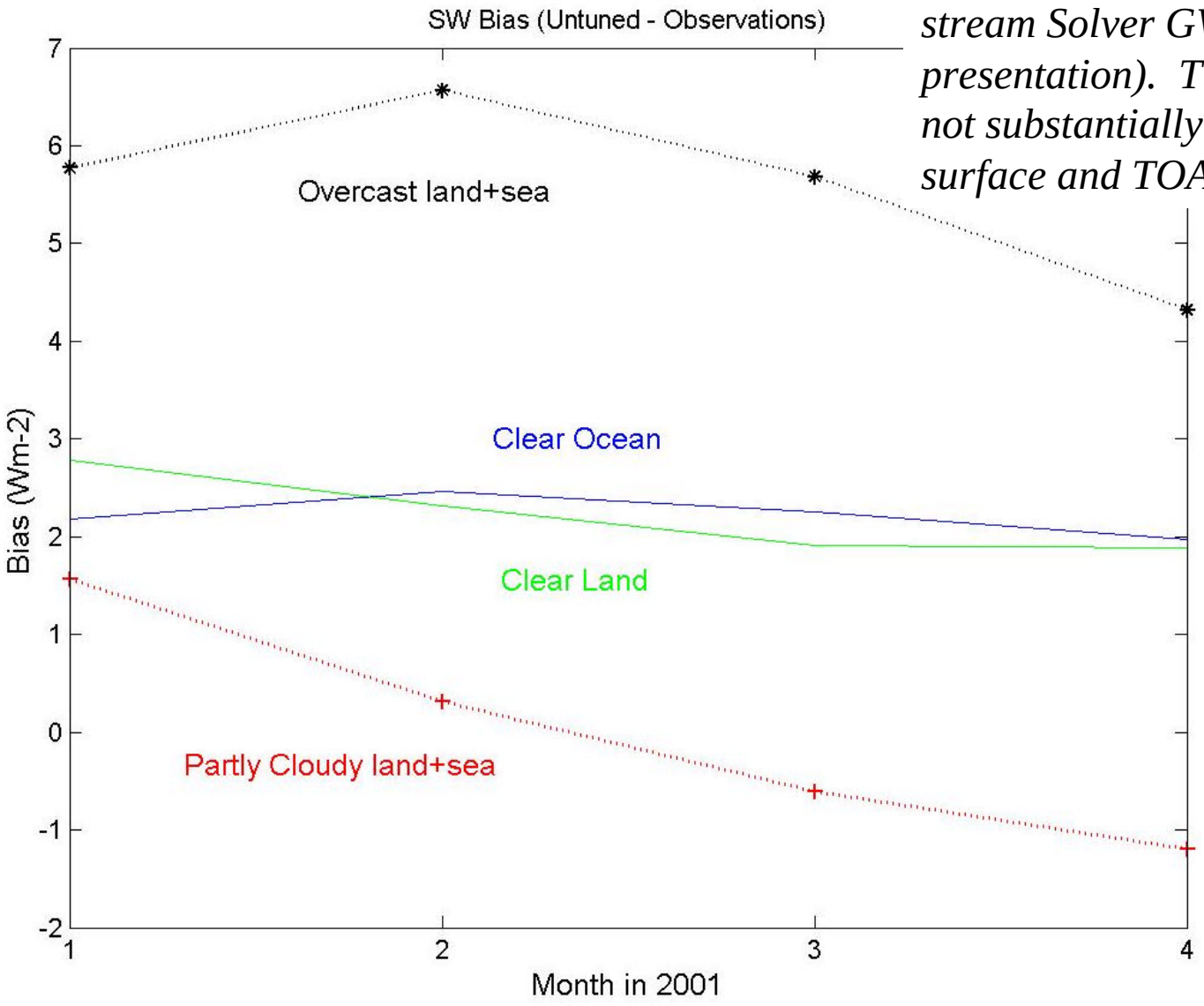
TOA Calculations and Observations in CRS TRMM Edition 2C and Terra Beta 5

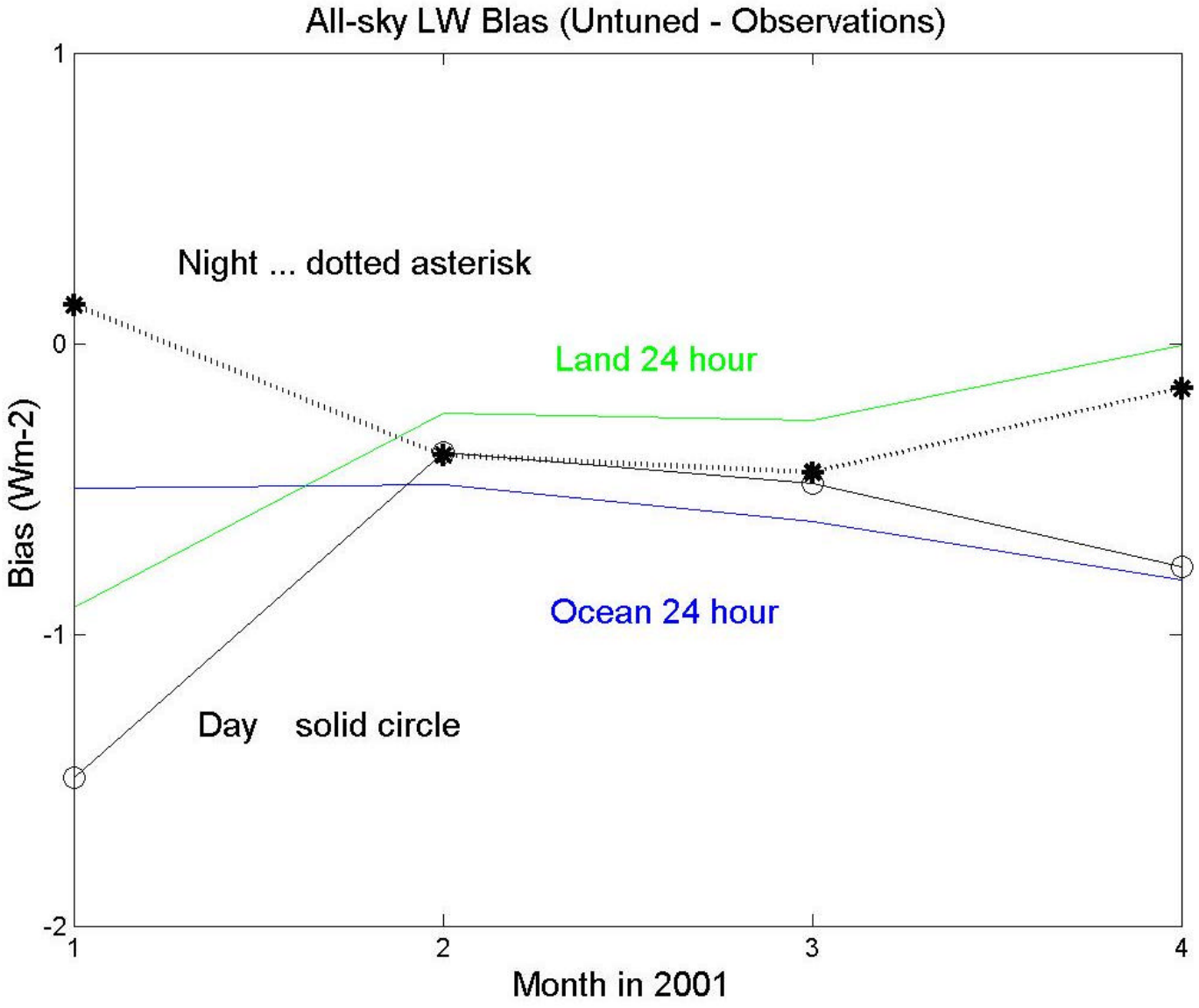


Remaining plots of production runs cover only Terra CRS Beta 5

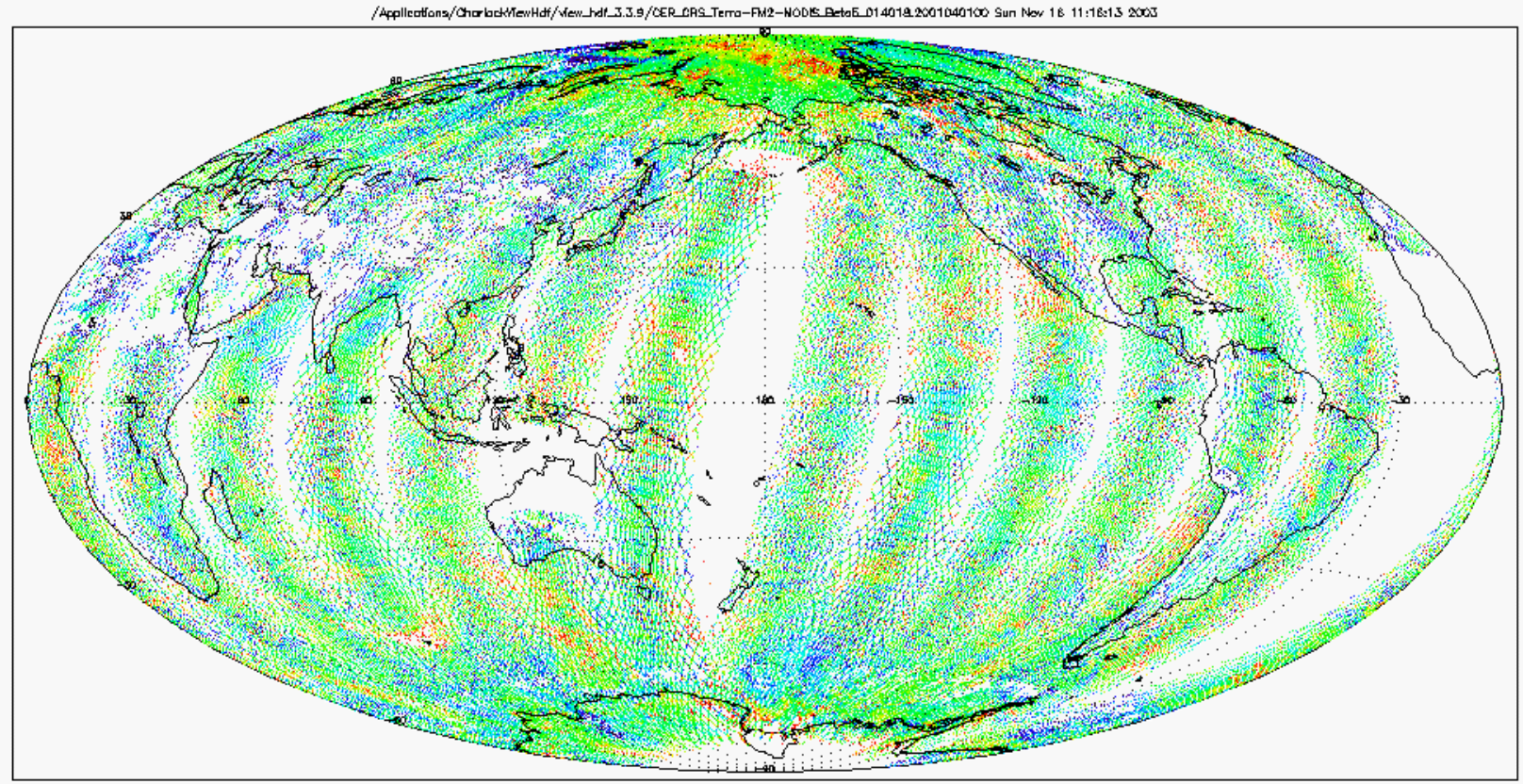


Large, compensating cloudy biases are partly corrected by tuning. ***Next*** *CRS will have Kato's Gamma Weighted Two-stream Solver GWTS (following presentation). Tuning and GWTS do not substantially change relationship of surface and TOA SW fluxes*

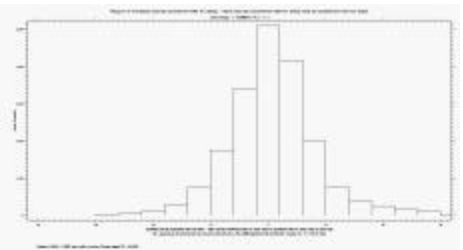



All-sky LW Blas (Untuned - Observations)
Night ... dotted asterisk
Land 24 hour
Ocean 24 hour
Day solid circle
Bias (Wm-2)
Month in 2001
1
0
-1
-2
1
2
3
4

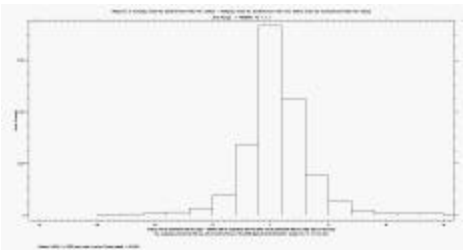
All sky OLR (Untuned - Observations) for Daytime 1 April 2001

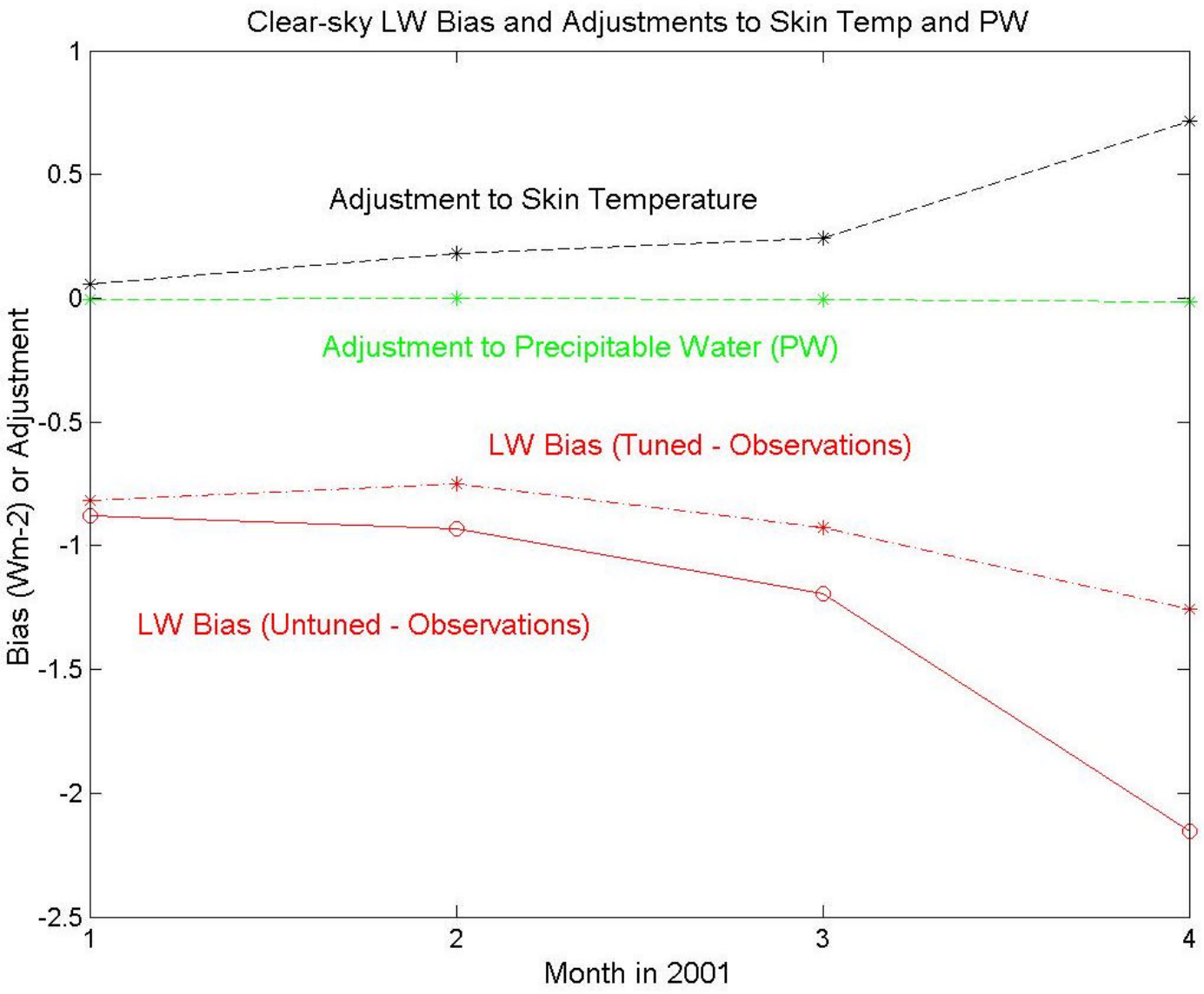


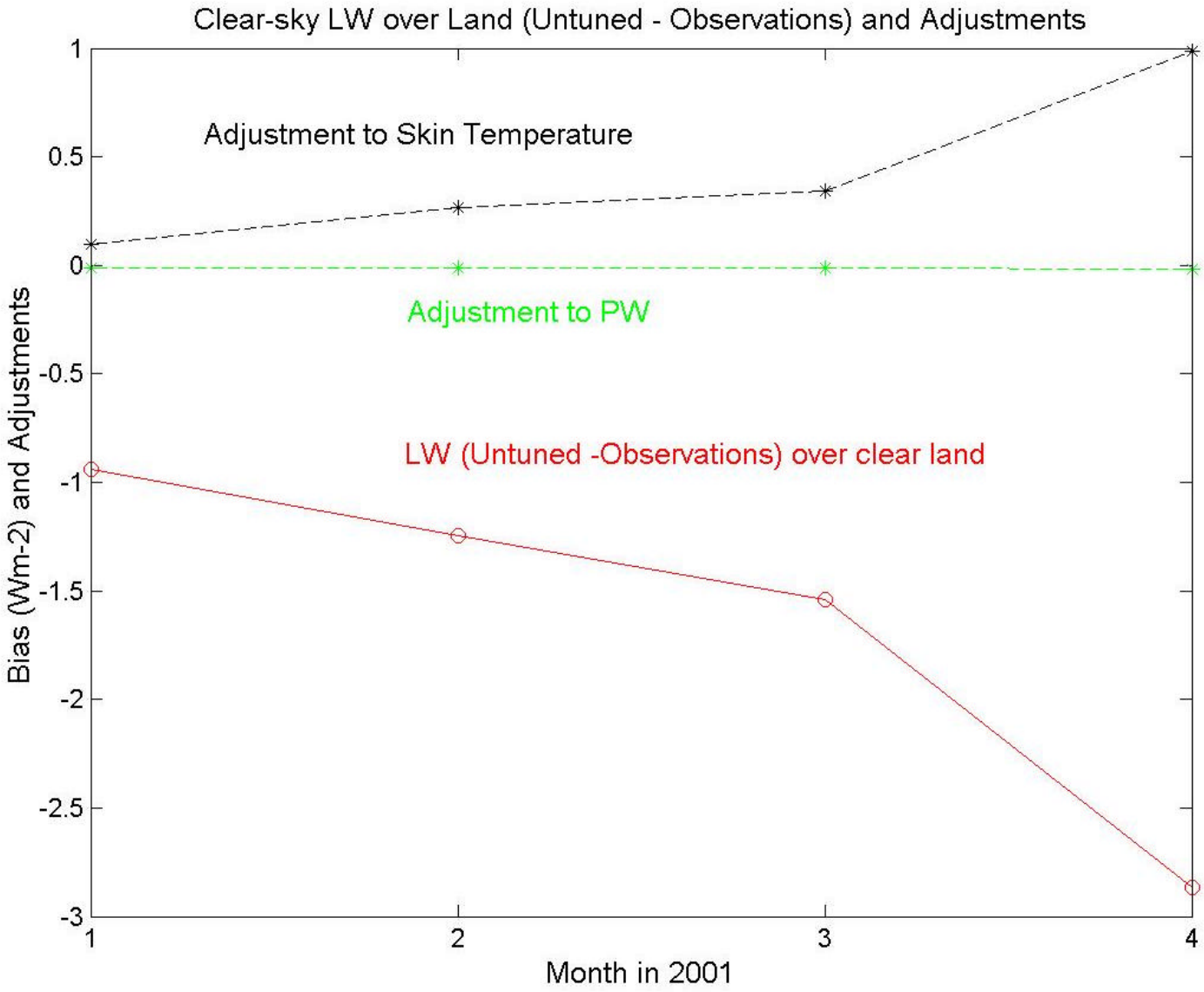
Day Std dev = 21.9



Nite Std dev = 10.5




Clear-sky LW Bias and Adjustments to Skin Temp and PW
Adjustment to Skin Temperature
Adjustment to Precipitable Water (PW)
LW Bias (Tuned - Observations)
LW Bias (Untuned - Observations)
Bias (Wm-2) or Adjustment
Month in 2001
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1
2
3
4


Clear-sky LW over Land (Untuned - Observations) and Adjustments
Adjustment to Skin Temperature
Adjustment to PW
LW (Untuned -Observations) over clear land
Bias (Wm-2) and Adjustments
Month in 2001
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
1
2
3
4

Previous plots were uncensored.

Plots & tables in format to right are censored. Unless noted, they do not include:

---Saudi Solar Village (aerosol disaster)

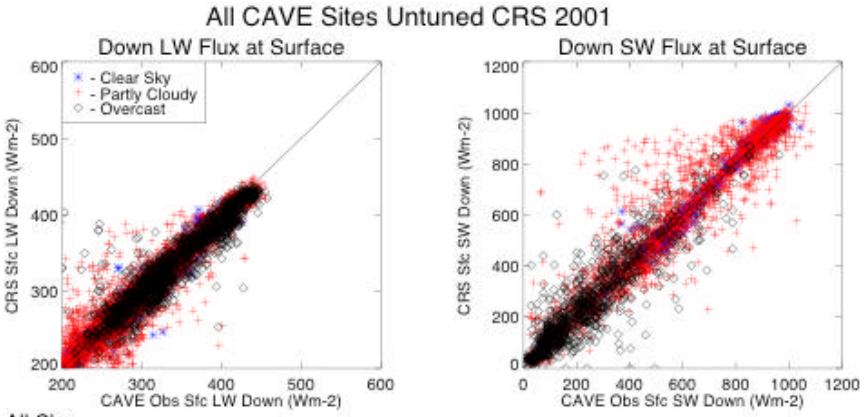
---Mauna Loa (mountain)

---ARM E22 (bad radiometers)

---and footprints where MODIS AOT > 0.4

The problem with aerosols over land:

SARB uses MODIS AOT in 3 visible channels to estimate Angstrom exponent and specify AOT in the near IR. Our method is sensible, but it often produces erroneous near IR values. We have the information to fix it.



All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	287.86	7931.00	0.93	25.61	25.62	25.57	26.39	26.47
LW Up Sfc	342.20	6235.00	4.44	29.57	29.90	--------	--------	--------
SW Dn Sfc	513.67	3986.00	12.40	84.00	84.90	-163.49	-151.09	84.90
SW Up Sfc	115.08	2952.00	-21.23	45.00	49.75	--------	--------	--------
LW Up TOA	216.93	8096.00	1.49	7.86	8.00	-27.46	-25.96	8.01
SW Up TOA	295.71	4112.00	4.72	33.05	33.38	110.35	115.08	33.38

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	273.13	1255.00	-0.20	19.27	19.26	--------	--------	1.44
LW Up Sfc	372.75	1122.00	2.27	31.05	31.12	--------	--------	--------
SW Dn Sfc	747.06	622.00	5.33	28.43	28.90	-22.03	27.39	-19.34
SW Up Sfc	143.01	543.00	-24.21	27.79	36.84	--------	--------	--------
LW Up TOA	260.28	1301.00	0.78	3.83	3.91	--------	--------	-0.30
SW Up TOA	176.04	630.00	3.40	5.40	6.38	--------	--------	7.40

Clear Sky MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	231.59	57.00	3.54	13.43	13.77	--------	--------	1.51
LW Up Sfc	358.95	56.00	9.32	24.82	26.30	--------	--------	--------
SW Dn Sfc	638.70	57.00	2.80	24.76	24.70	-43.57	46.37	-19.42
SW Up Sfc	135.93	48.00	-31.25	30.26	43.28	--------	--------	--------
LW Up TOA	254.14	57.00	2.98	6.28	6.90	--------	--------	-0.52
SW Up TOA	179.18	57.00	6.82	6.97	9.71	--------	--------	9.35

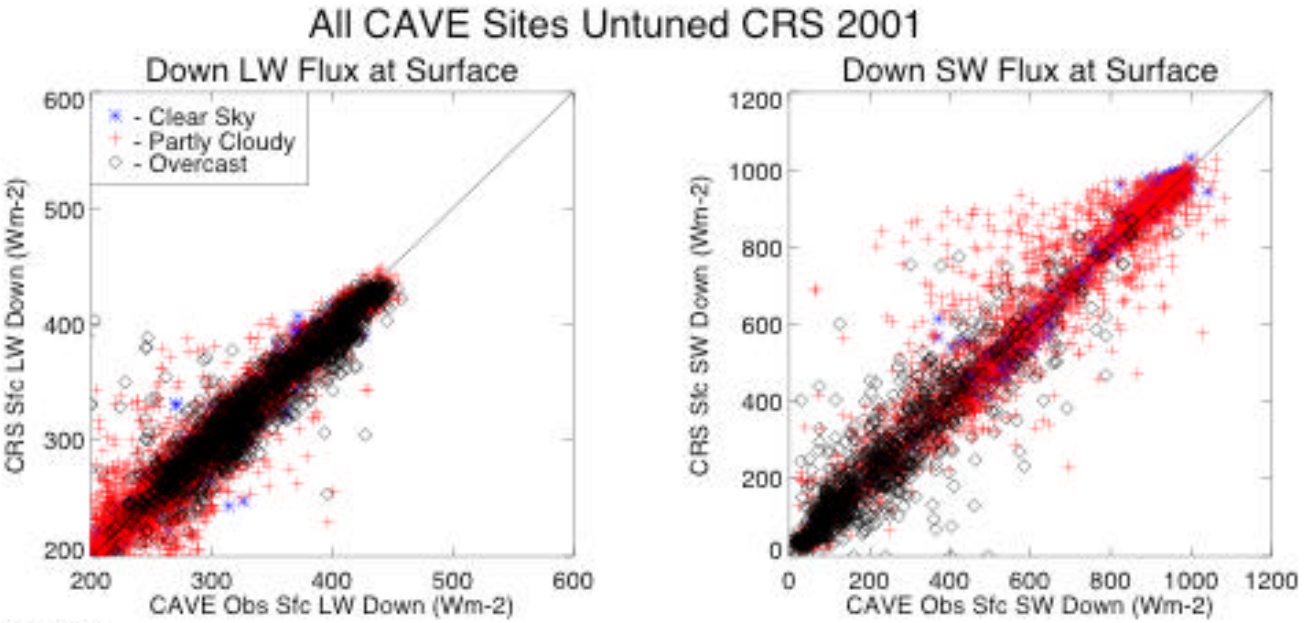
Overcast MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	326.50	1993.00	-2.11	25.16	25.24	46.51	43.98	28.49
LW Up Sfc	347.12	1609.00	11.98	28.29	30.72	--------	--------	--------
SW Dn Sfc	259.72	1083.00	8.62	82.85	83.25	-383.70	-375.08	83.25
SW Up Sfc	70.12	882.00	-13.60	40.74	42.93	--------	--------	--------
LW Up TOA	179.70	2036.00	-0.14	7.72	7.72	-67.26	-67.37	7.74
SW Up TOA	450.35	1132.00	13.80	42.51	44.68	273.78	287.58	44.68

Overcast MODIS & L/AA

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	339.74	392.00	-0.30	23.63	23.60	57.18	56.88	23.60
LW Up Sfc	351.02	329.00	19.55	33.26	38.54	--------	--------	--------
SW Dn Sfc	179.87	368.00	20.29	82.73	85.07	-552.15	-531.86	85.07
SW Up Sfc	39.60	311.00	-7.30	34.81	35.51	--------	--------	--------
LW Up TOA	184.38	393.00	0.71	8.60	8.62	-67.47	-66.76	8.62
SW Up TOA	555.16	393.00	25.50	31.58	40.56	379.97	405.47	40.56

The censored plots and tables cover CRS Beta5 from 1 Jan. 2001 to 15 June 2001



All Sky

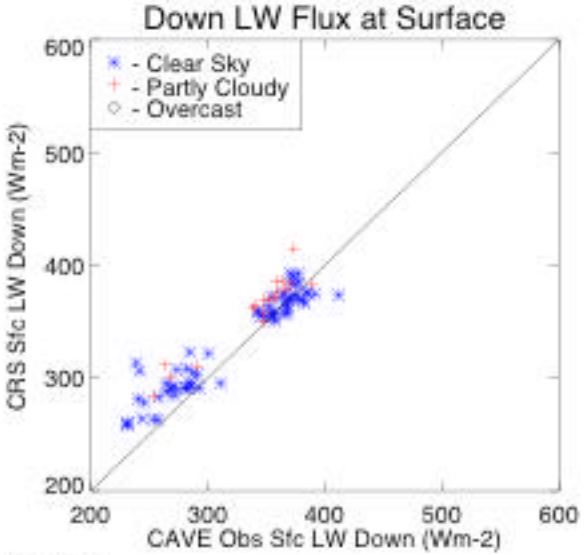
	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	287.86	7931.00	0.93	25.61	25.62	25.57	26.39	26.47
LW Up Sfc	342.20	6235.00	4.44	29.57	29.90	--------	--------	--------
SW Dn Sfc	513.67	3986.00	12.40	84.00	84.90	-163.49	-151.09	84.90
SW Up Sfc	115.08	2952.00	-21.23	45.00	49.75	--------	--------	--------
LW Up TOA	216.93	8096.00	1.49	7.86	8.00	-27.46	-25.96	8.01
SW Up TOA	295.71	4112.00	4.72	33.05	33.38	110.35	115.08	33.38

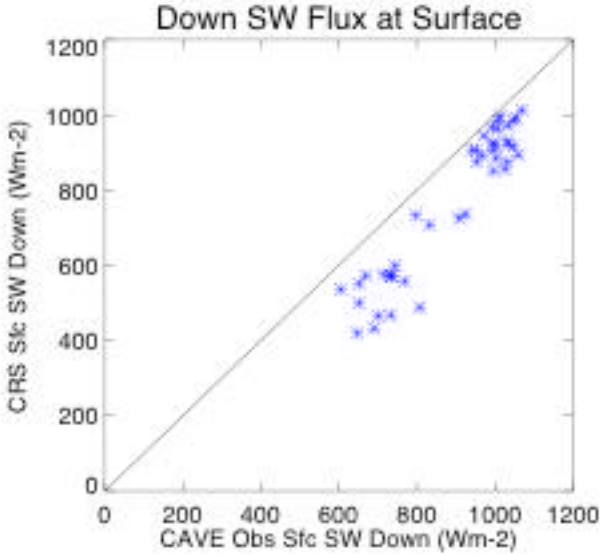
Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	273.13	1255.00	-0.20	19.27	19.26	--------	--------	1.44
LW Up Sfc	372.75	1122.00	2.27	31.05	31.12	--------	--------	--------
SW Dn Sfc	747.06	622.00	5.33	28.43	28.90	-22.03	27.39	-19.34
SW Up Sfc	143.01	543.00	-24.21	27.79	36.84	--------	--------	--------
LW Up TOA	260.28	1301.00	0.78	3.83	3.91	--------	--------	-0.30
SW Up TOA	176.04	630.00	3.40	5.40	6.38	--------	--------	7.40

MOST SECRET: Why we need the Patriot Axe.

Saudi Solar Village, (NREL) Untuned CRS 2001





All Sky

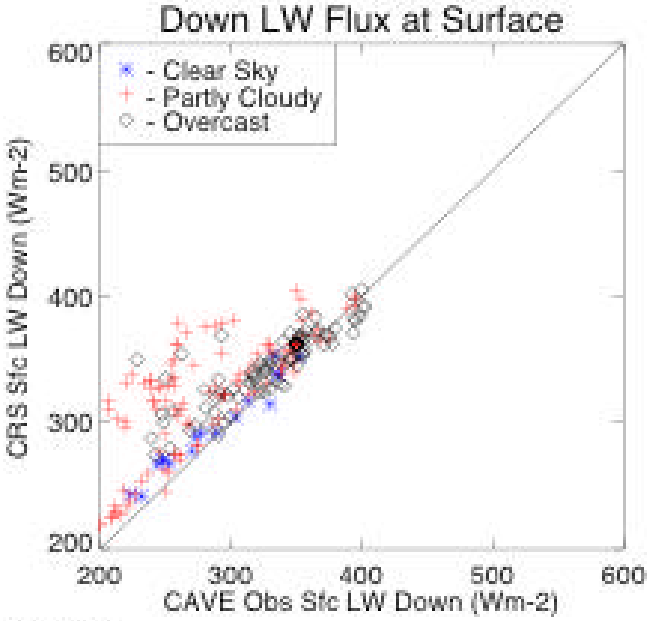
	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	326.24	84.00	12.86	17.61	21.72	-11.82	1.04	21.72
LW Up Sfc	460.87	84.00	5.82	19.10	19.86	--------	--------	--------
SW Dn Sfc	892.81	44.00	-119.69	72.50	139.50	119.69	0.00	139.50
SW Up Sfc	225.01	20.00	-44.22	25.05	50.51	--------	--------	--------
LW Up TOA	305.69	84.00	-21.25	9.93	23.43	19.65	-1.60	23.43
SW Up TOA	308.82	44.00	10.88	12.08	16.15	-10.88	0.00	16.15

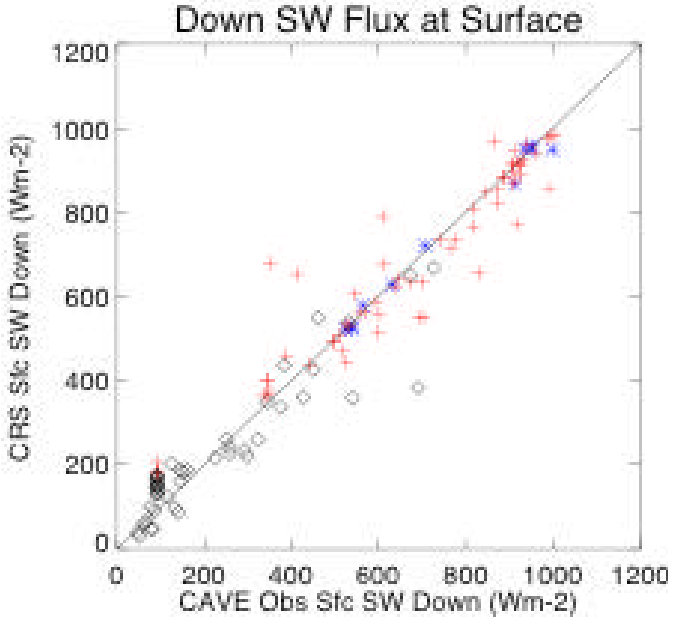
Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	321.62	65.00	10.78	18.36	21.17	--------	--------	28.15
LW Up Sfc	466.76	65.00	10.23	18.85	21.32	--------	--------	--------
SW Dn Sfc	890.02	43.00	-121.13	72.72	140.84	-320.16	199.03	-162.16
SW Up Sfc	221.08	19.00	-44.57	25.68	51.10	--------	--------	--------
LW Up TOA	310.64	65.00	-22.23	10.59	24.59	--------	--------	-20.45
SW Up TOA	308.19	43.00	12.43	6.42	13.95	--------	--------	-32.05

LW AOT forcing is not due to the “Angstrom Interpolation bug”, but OLR error remains large.

Chesapeake Light (LaRC) Untuned CRS 2001





All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	303.23	222.00	27.47	31.56	41.78	12.45	39.92	41.78
LW Up Sfc	359.58	223.00	43.51	26.54	50.94	--------	--------	--------
SW Dn Sfc	504.35	122.00	0.17	73.80	73.50	-265.39	-265.22	73.50
SW Up Sfc	23.02	121.00	0.49	5.67	5.67	--------	--------	--------
LW Up TOA	228.89	224.00	1.83	11.17	11.30	-38.62	-36.79	11.30
SW Up TOA	309.72	123.00	21.16	32.66	38.81	215.09	236.26	38.81

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	286.03	17.00	9.72	10.58	14.13	--------	--------	1.77
LW Up Sfc	376.59	17.00	22.58	32.40	38.70	--------	--------	--------
SW Dn Sfc	750.65	11.00	-7.33	22.37	22.56	-7.89	-0.13	-20.48
SW Up Sfc	32.60	11.00	-0.74	3.02	2.97	--------	--------	--------
LW Up TOA	263.73	17.00	8.48	9.47	12.50	--------	--------	-0.42
SW Up TOA	77.39	11.00	14.87	10.37	17.85	--------	--------	10.91

COVE Untuned: note bias in SW at TOA

All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	303.23	222.00	27.47	31.56	41.78	12.45	39.92	41.78
LW Up Sfc	359.58	223.00	43.51	26.54	50.94	--------	--------	--------
SW Dn Sfc	504.35	122.00	0.17	73.80	73.50	-265.39	-265.22	73.50
SW Up Sfc	23.02	121.00	0.49	5.67	5.67	--------	--------	--------
LW Up TOA	228.89	224.00	1.83	11.17	11.30	-38.62	-36.79	11.30
SW Up TOA	309.72	123.00	21.16	32.66	38.81	215.09	236.26	38.81

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	286.03	17.00	9.72	10.58	14.13	--------	--------	1.77
LW Up Sfc	376.59	17.00	22.58	32.40	38.70	--------	--------	--------
SW Dn Sfc	750.65	11.00	-7.33	22.37	22.56	-7.89	-0.13	-20.48
SW Up Sfc	32.60	11.00	-0.74	3.02	2.97	--------	--------	--------
LW Up TOA	263.73	17.00	8.48	9.47	12.50	--------	--------	-0.42
SW Up TOA	77.39	11.00	14.87	10.37	17.85	--------	--------	10.91

COVE Tuned: SW bias at surface is larger

All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	303.23	222.00	28.39	31.93	42.67	11.47	39.85	42.67
LW Up Sfc	359.58	223.00	40.92	26.50	48.72	--------	--------	--------
SW Dn Sfc	504.35	122.00	15.72	87.74	88.79	-262.23	-246.51	88.79
SW Up Sfc	23.02	121.00	1.25	6.17	6.27	--------	--------	--------
LW Up TOA	228.89	224.00	2.10	6.36	6.68	-37.56	-35.46	6.68
SW Up TOA	309.72	123.00	1.46	14.24	14.25	214.71	216.17	14.25

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	286.03	17.00	13.91	14.54	19.81	--------	--------	1.10
LW Up Sfc	376.59	17.00	9.72	20.02	21.72	--------	--------	--------
SW Dn Sfc	750.65	11.00	-4.47	23.81	23.14	-5.35	-0.07	-10.88
SW Up Sfc	32.60	11.00	-1.60	2.94	3.23	--------	--------	--------
LW Up TOA	263.73	17.00	3.17	4.20	5.16	--------	--------	-0.22
SW Up TOA	77.39	11.00	7.56	4.98	8.92	--------	--------	4.86

Off line calculations for July 2001 CLAMS field campaign

Not CRS: Up to 13 Fu-Liou cloudy calculations per footprint (SST tau histogram)

Special CERES scan for multiple views on each day

Large or land contaminated FOVs discarded

GFDL ocean gridbox used to apportion aerosol type for g and ssa

CERES FOV Average (several snapshots on each of 18 days)	N FOVs	TOA Wm-2	Surface Wm-2	Direct Wm-2	Diffuse Wm-2
Observations	282	180	812	546	267
Model (MODIS τ)					
Model-Observations	282	-1	-3	-20	17
RMS error	282	21	61	101	73
Model (AERONET τ)					
Model-Observations	282	-1	1	2	-1
RMS error	282	20	75	115	72

ARM SGP E13 Untuned

All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	317.05	213.00	-3.57	14.06	14.47	23.43	19.86	14.47
LW Up Sfc	382.78	213.00	1.69	17.93	17.97	--------	--------	--------
SW Dn Sfc	575.96	109.00	-0.94	80.31	79.94	-190.02	-190.96	79.94
SW Up Sfc	109.84	108.00	-21.79	25.60	33.53	--------	--------	--------
LW Up TOA	226.49	213.00	1.06	6.88	6.95	-34.21	-33.15	6.95
SW Up TOA	328.36	108.00	-1.36	27.57	27.47	158.61	157.25	27.47

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	286.90	57.00	-1.80	8.11	8.24	--------	--------	1.48
LW Up Sfc	382.06	57.00	-1.19	9.00	9.00	--------	--------	--------
SW Dn Sfc	772.33	26.00	10.26	24.13	25.79	-22.42	32.68	-21.05
SW Up Sfc	150.18	25.00	-20.27	17.03	26.26	--------	--------	--------
LW Up TOA	264.28	57.00	0.50	2.55	2.57	--------	--------	-0.28
SW Up TOA	182.58	26.00	4.03	5.14	6.45	--------	--------	6.82

Syowa (10 km from Antarctic coast) Untuned

All Sky

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Obs Frc All-Clr	Mod Frc All-Clr	Forcing RMS
LW Dn Sfc	237.87	428.00	-9.12	27.43	28.88	48.94	38.08	36.00
LW Up Sfc	--------	--------	--------	--------	--------	--------	--------	--------
SW Dn Sfc	270.30	192.00	-0.43	86.36	86.14	-75.47	-75.90	86.14
SW Up Sfc	--------	--------	--------	--------	--------	--------	--------	--------
LW Up TOA	187.21	441.00	6.25	10.70	12.38	-27.25	-21.01	12.38
SW Up TOA	294.69	197.00	-39.25	91.32	99.19	88.98	49.72	99.19

Clear Sky MODIS

	Obs Mean	N	Bias CRS-Obs	Std Dev	RMS	Dir Bias CRS-Obs	Dif Bias CRS-Obs	AOT Frc Clr-Prs
LW Dn Sfc	173.29	14.00	-8.96	25.54	26.19	--------	--------	0.28
LW Up Sfc	--------	--------	--------	--------	--------	--------	--------	--------
SW Dn Sfc	285.79	2.00	-12.69	18.31	18.13	-13.84	1.15	-7.94
SW Up Sfc	--------	--------	--------	--------	--------	--------	--------	--------
LW Up TOA	187.63	14.00	5.34	9.67	10.74	--------	--------	-0.03
SW Up TOA	217.65	2.00	6.71	0.94	6.74	--------	--------	1.84